

Corrosion in Multiphase Systems Center (CMSC)

Ohio University and the University of Illinois at Urbana–Champaign

Measurements of corrosion and flow parameters and modeling of the effect of multiphase environments on corrosion processes and mechanisms

Center Mission and Rationale

Many industrial processes involve multiphase environments, i.e., liquid/liquid, gas/liquid, solid/liquid, etc. The flow and corrosion aspects of these systems are usually studied in the laboratory using single-phase analogies and associated techniques. The results from these studies, when applied to the large-scale multiphase facilities, have often led to significant under-prediction of the corrosion. This is due to the different mechanisms in single and multiphase systems.

The Center was established to provide pilot- and full-scale facilities for the study of corrosion and the associated flow effects in all types of multiphase environments. These large-scale flow facilities and environmental chambers are used to provide data and subsequent modeling of both the flow and corrosion. Novel visual techniques and observations allow the identification of the mechanisms that contribute to the corrosion processes.

Research Program

The Center has a multidisciplinary research team that comprises faculty, technical staff, post-doctoral persons, and graduate and undergraduate students from engineering (Chemical, Nuclear, and Civil) and science departments (Chemistry and Physics). The research projects receive strong direction from the Industrial Advisory Board and constitute research in the following areas:

Oil and Gas Industry — Internal corrosion and multiphase flow in horizontal, vertical, and inclined pipes, tubulars, and wells.

Multiphase Flow Characteristics —

- Identification of flow regimes in large-diameter, two-phase liquid/liquid and three-phase gas/liquid/liquid flow systems at any inclination
- Determination of the distribution of the phases
- Measurements of gas and liquid fractions, pressure gradient, average and instantaneous wall shear stress and turbulence intensity
- Characterization of slug flow, slug frequency, slug length, liquid holdup and void fraction, and the effect of inclination
- Effect of temperature and pressure on flow regime transitions, flow characteristics, and phase distribution
- Mechanistic modelling and software development of 3 phase flows.

Corrosion/Erosion —

- Measurement of corrosion rates using electro-chemical, electrical resistance, and coupon methods
- Effect of flow regime on corrosion
- Effect of flow velocity, pressure, temperature, pH, and phase distribution on mass transfer and corrosion
- Effect of wall shear and turbulence on corrosion mechanisms
- Identification of corrosion products using visual methods and SEM, TEM, and ESCA microscopy



The Center's high-pressure, inclinable, three-phase flow and corrosion facility

- Determination of corrosion processes
- Modelling and prediction of corrosion in large-diameter, high pressure, inclined, multiphase pipelines and tubes.

Corrosion Inhibition and Material Selection —

- Evaluation of the performance and effectiveness of corrosion inhibitors
- Effect of multiphase flow on corrosion inhibitor performance
- Development of environmentally friendly, "green" inhibitors
- Effect of drag-reducing agents and surfactants on corrosion.

Instrumentation —

- Development of new, combined corrosion and flow sensors
- In-line sensors for measuring wall shear stress and turbulence for multiphase systems
- High-speed video techniques for the determination of flow characteristics and corrosion mechanics

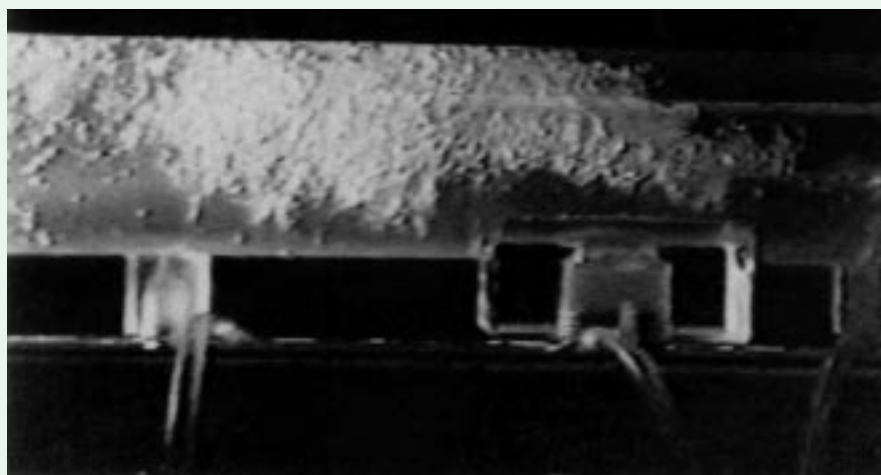
- Image analysis techniques for velocity profiles, gas and liquid fraction
- Development of ultrasonic flow metering system for multiphase flow.

Animal and Plant Facilities

- Identification of corrosion mechanisms and processes at roof, floor, and manure pit levels
- Effect of chemical species on corrosion rates
- Identification of bacteria colonies and biofilm build-up using SEM, ESCA
- Effect of bacteria on corrosion.

Facilities

- 7.5, 10, and 15 cm diameter, horizontal acrylic multiphase flow systems that operate up to 5 bar and 60°C with oil and water velocities up to 3 m/s and gas velocity 30 m/s
- 10 cm diameter 316 stainless steel horizontal three-phase flow loop that operates up to 100 bar and 90°C with oil and water velocities up to 3 m/s and gas velocity 30 m/s
- 10 cm diameter acrylic inclined three-phase flow loop that operates up to 5 bar and 60°C with oil and water velocities up to 3 m/s and gas velocity 30 m/s. The range of inclination is -90 to +90 degrees
- 10 cm diameter 316 stainless steel inclined three-phase flow loop that operates up to 150 bar and 90°C with oil and water velocities up to 3 m/s and gas velocity 30 m/s. The range of inclination is -90 to +90 degrees.
- Environmental chambers for studying



Video image of the mixing zone of a slug in a horizontal pipeline

accelerated corrosion in buildings using any gas, liquid, or solid.

Special Center Activities

The Center provides corrosion and multiphase flow courses to transfer the technology from the Center's projects for use in the field. Special narrated videos have been produced for educational purposes for the member companies.

The Center engages in special individual and group projects outside the normal program, as specified by the companies. These have included the calculation of wall shear forces and their effect on corrosion at pipe upsets. An example is shown.

Novel instrumentation is being developed to study the combined flow characteristics and the corrosion mechanisms.

Interactive software has been produced based on the mechanistic models developed by the Center. This includes the prediction of the water layer thickness in stratified three-phase flow and the modeling of corrosion in large-diameter, high-pressure pipelines.

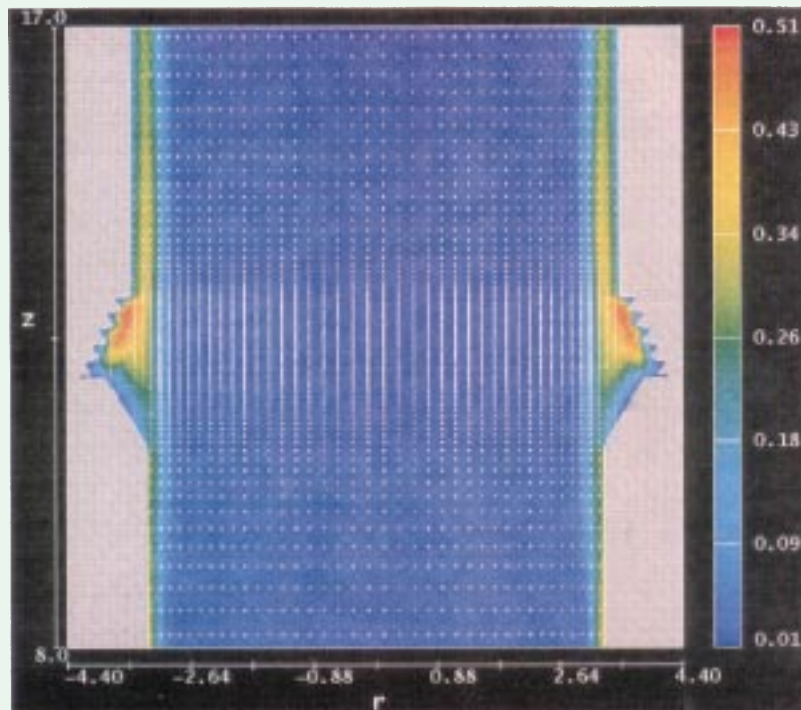
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Simulation of turbulence dissipation around piping upset in oil production